

## REMARKS/ARGUMENTS

Reconsideration of this patent application is respectfully requested in view of the foregoing amendments.

The specification has been objected to for failure to conform with current U.S. practice. Applicant encloses herewith a clean copy and a marked-up copy of a Substitute Specification. No new matter has been added.

Claims 8-13 have been rejected under 35 U.S.C. § 112, second paragraph, for the reasons set forth on page 2 of the Office Action. It was unclear to the Examiner as to the number of cylinders and pistons in the claimed combination. Claim 8 has been amended incorporating the Examiner's suggestions, and claims 9-13 depend upon amended claim 8. It is respectfully submitted that all currently pending claims fully comply with 35 U.S.C. § 112, second paragraph, and Applicant respectfully requests that the Examiner's rejection on this basis be withdrawn.

Claims 8-13 were rejected under 35 U.S.C. 103(a) as being unpatentable over *Bosch* (FR Patent No. 1,391,410) in view of

*Reid* (U.S. Patent No. 2,859,061). Essentially, the Examiner's position was that *Bosch* discloses the combination valve, piston, cylinder and annular gap seal, except for the claimed groove in the cylinder, that *Reid* discloses this feature, and that it would have been obvious to one of ordinary skill in the art to modify *Bosch* with the groove disclosed by *Reid* as a matter of mechanical experience and to reduce manufacturing costs.

This rejection is respectfully traversed.

As set forth in amended claim 8, Applicant's invention provides a groove having an axially projecting peripheral lug on both sides to which the undercut form of the groove is due. The groove prevents an egression of the seal out of the groove.

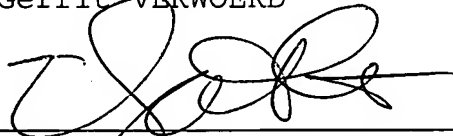
None of the cited references discloses or suggests a groove having an axially projecting peripheral lug on both sides. *Bosch* discloses a groove exactly rectangular; only the sealing rings show lugs 13, 14 so that an undercut sealing is formed. The lugs on the sealing rings in *Bosch* are not the same as the lugs on the groove in the present invention. The defects and deficiencies of the *Bosch* are nowhere remedied by *Reid*. *Reid* discloses grooves

in a cylinder or piston, the groove being rectangular.

In summary, claim 8 has been amended. None of the cited references discloses or suggests Applicant's device as recited in amended claim 8, that includes a groove having an axially projecting peripheral lug on both sides. Accordingly, it is respectfully submitted that amended claim 8 together with claims 9-13, which depend directly or indirectly thereon, are patentable over the cited references.

In summary, claim 8 has been amended. In view of the foregoing, withdrawal of the final action and allowance of this application are respectfully requested.


Respectfully submitted,  
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## SUBSTITUTE SPECIFICATION

~~Annular gap seal for a valve~~

### CROSS REFERENCE TO RELATED APPLICATIONS

Applicant claims priority under 35 U.S.C. § 119 of German Application No. 103 12 753.4 filed on March 21, 2003. Applicants also claim priority under 35 U.S.C. §365 of PCT/EP04/02704 filed on March 16, 2004.

### [[--]]BACKGROUND OF THE INVENTION[[ - -]]

The present invention relates to an annular gap seal for a valve, which may block while in a blocked position ~~using which~~ the flow of a fluid from a high-pressure side to a low-pressure side of the valve ~~may be blocked in a blocked position~~, the valve having a cylinder which the fluid may flow through and in which a piston is axially displaceable, and an annular gap between the piston and the cylinder being sealable in the blocked position using the annular gap seal, which lies in a groove around the circumference of the cylinder.

Annular gap seals of this type for valves are generally known.

German patent DE 37 31 349 A1 discloses a trapezoidal annular gap seal, for example, ~~which also lies~~ lying in a trapezoidal groove and which may be placed under a pre-tension using a lock washer. German patent DE 29 29 389 A1 discloses a ~~A~~-regulating valve, in which an annular gap seal of this type is typically used, ~~is disclosed, for example, in DE 29 29 389 A1.~~

The known annular gap seals have leakage flows in the blocked position, which are tolerated less and less for reasons of quality assurance in industrial production and control processes. The causes of these leakage flows are, ~~in addition to~~ (1) the occurrence of wear and aging on the seal elements, (2) insufficient radial adjustment capability of the known annular gap seals and (3) inadequate consistency of their material properties upon changes of the operating temperature.

In addition, the known annular gap seals - precisely because of the leakage flows - are only capable of securing facility parts from backf lows in a very limited way.

[[--]]SUMMARY OF THE INVENTION[-]

The object of the present invention is to provide ~~based on the object of suggesting an annular gap seal which ensures tightness both in the intended flow direction and also opposite the intended flow direction and, for this purpose, particularly minimizes the leakage flows, even at different operating temperatures.~~

~~On the basis of the known annular gap seal, this~~ This object is achieved according to the present invention by two sealing rings positioned mirror-symmetrically in the groove next to one another, a sealing lip of a first sealing ring facing toward the low-pressure side being able to be pressed fluid-tight against the piston, and a sealing surface of the first sealing ring being able to be pressed fluid-tight against a groove wall in the blocked position by the fluid from the high-pressure side.

Design optimization is possible as a result of the division of the annular gap seal into two sealing rings. This allows for a self-reinforcement effect of the sealing action upon increasing pressure differential between the high-pressure side and the low pressure side. ~~The division of the annular gap seal into two sealing rings allows design optimization in regard to a self-reinforcement effect of the sealing action upon increasing~~

~~pressure differential between the high-pressure side and the low-~~  
~~pressure side.~~ Through the symmetrical design, the annular gap  
seal according to the present invention acts equally effectively  
in the intended flow direction and opposite the intended flow  
direction.

~~The~~ This annular gap seal ~~according to the present invention is~~  
preferably designed in such a way that while in the blocked  
position, a sealing shoulder of the first sealing ring facing  
toward the low-pressure side may be pressed fluid-tight against a  
peripheral lug, which projecting projects axially into the  
groove, by the fluid from the high-pressure side. The pairing of  
a sealing shoulder with a peripheral lug in the groove ensures a  
further elevated sealing action between the sealing ring and the  
groove wall on the valve housing.

The sealing rings of the annular gap seal ~~according to the~~  
~~present invention especially advantageously~~ have C-profiles and  
the C-profile of the first sealing ring facing toward the low-  
pressure side is expandable in the blocked position by the fluid  
from the high-pressure side. Through the expansion, the sealing  
ring of the annular gap seal ~~according to the present invention~~  
is additionally clamped between the groove base and the mantle

surface of the piston, through which the sealing action between sealing ring and groove base - i.e., housing - and mantle is further elevated.

Oversized dimensions of the annular gap seal ~~according to the present invention~~ in relation to the distance between piston and groove base are also used ~~especially simply~~ for increasing the sealing action, so that the annular gap seal may be laid in the groove with pre-tension.

In an ~~especially~~ another preferred embodiment, the annular gap seal ~~according to the present invention~~ has a stabilizing element, which may be laid in the direction of the groove with the sealing rings. Such a stabilizing element is preferably made of a material whose properties are subjected to extremely slight variations in the scope of the operating temperatures. In manifold applications, steel has particularly proven itself as a material whose aging and media resistance may additionally be increased by different alloys in a generally known way and adapted to the requirements.

The stabilizing element is ~~especially~~ preferably a coiled spring which may be inserted in a torus shape. The coiled spring



particularly allows the sealing lips of the sealing rings to be pre-tensioned in the direction of the piston.

[[--]]BRIEF DESCRIPTION OF THE DRAWINGS[[--]]

Other objects and features of the present invention will become apparent from the following detailed description considered in connection with the accompanying drawings. It is to be understood, however, that the drawings are designed as an illustration only and not as a definition of the limits of the inventions.

The present invention will be explained in the following on the basis of an exemplary embodiment.

Figure 1a shows a sectional illustration of a valve having the annular gap seal according to the present invention,

Figure 1b shows the broader environment of the annular gap seal in this valve,

Figure 1c shows the narrower environment of the annular gap

seal in this valve,

Figure 2 shows an exploded sectional illustration of the annular gap seal,

Figure 3a shows the stabilizing element of the annular gap seal, ~~and~~

Figure 3b shows a further view of the stabilizing element,

Figure 4a shows a detail view of the annular gap seal with an open valve,

Figure 4b shows this detail view in the blocked position under normal pressure conditions and

Figure 4c shows this detail view in the blocked position with flow against the intended flow direction.

[[--]] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS[[--]]

Figure 1 shows a valve 1, which regulates ~~using which~~ the flow of

a fluid (not shown) from a valve intake 2 to a valve outlet 3 of the valve 1 ~~may be regulated~~. The identifications of valve intake 2 and valve outlet 3 relate to the intended flow direction 4 of the fluid through the valve 1, in which maximum flow rates and minimum wear of the valve 1 are implemented in the open position of the valve 1 shown here. The valve 1 shown as an example has a nominal diameter 5 of 24 inches, flange surfaces 6 in accordance with ANSI 900 RTJ for a rated pressure of 900 psi at the valve intake 2 and valve outlet 3, and a total length 7 of 1568 mm between the flange surfaces 6. Valves having identical construction in principle, having nominal diameters between 2 and 48 inches for rated pressures of 150 to 2500 psi, are used for flow regulation of oil, gas, or water or of multiphase mixtures. Alternatively, the valve may also be implemented according to the API standard.

The valve 1 has a cylinder 9, which the fluid may flow through, in a cast housing 8. The fluid penetrates radially through a section implemented as a cage 10 into the cylinder 9 and leaves it - and the valve 1 - in the intended flow direction 4. The cage 10 is fixed in the housing 8 using a type of locknut in the outlet bush 11 of the cylinder 9 screwed into the housing 8 of the valve 1.

A piston 12 is axially displaceable in the cylinder 9. The piston 12 has no front face and is permanently connected to an axially running piston rod 14 using radially running spokes 13. The piston rod 14 has a planar surface 15 spiral geared at 45°, which engages with a planar surface 16, which is also spiral geared at 45° of a radially running and radially displaceable switch rod 17. A linear radial movement of the switch rod 17 thus directly causes a linear axial movement of the piston rod 14 without hysteresis and play and therefore allows exact positioning of the piston 12 in the cylinder 9.

The piston 12, the piston rod 14, and the switch rod 17 are in force equilibrium in every operating position. Independently of the applied pressure ratios, the valve 1 is switchable unrestrictedly, and the speed of the switching procedure is restricted on the part of the valve 1 solely by the mass inertia of the piston 12, the piston rod 14, and the switch rod 17.

Upon displacement of the piston 12 in the cylinder 9, its mantle surface 18 closes the openings (not shown) in the cage 10 and thus blocks the flow of the fluid through the valve 1 in the blocked position. In the blocked position, the annular gap 19 remaining between the mantle surface 18 of the piston 12 and the

cylinder 9 is sealable using an annular gap seal 20. The cylinder 9 in the blocked position and the annular gap 19 to the cylinder 9 formed in this position are exclusively shown in the detail view 4 b and 4c.

The annular gap seal 20 - as shown in detail views 1b and 1c - lies in a peripheral groove 21 of the cylinder 9, which is implemented between the cage 10 and the outlet bush 11. Using a lip seal 23 positioned in a second groove 22 between the cage 10 and the outlet bush 11, these elements are sealed in relation to the housing 8.

The annular gap seal 20, which is shown in Figure 2 in a profile section like an exploded drawing, comprises an inner sealing ring 24 - in relation to the valve 1 - and a mirror-symmetric outer sealing ring 25. Both rings 24, 25 are made of polypropylene and their shapes are stabilized using a stabilizing element 26. ~~which are made of polypropylene and whose shapes are stabilized using a stabilizing element 26, for example.~~ Each sealing ring 24, 25 has a sealing lip 27, which may be pressed fluid-tight on the mantle surface 18 of the piston 12 in the blocked position. A C-profile 28 adjoins the sealing lip 27, whose outer sealing surface 29 is tailored to the shape of the lateral groove wall 30

and may be pressed fluid-tight thereon. The C-profile 28 forms a sealing shoulder 31 below the sealing lip 27, which is tailored to the shape of a peripheral lug 32, which projects axially into the groove 21 and may be pressed fluid-tight thereon. The C-profile 28 ends in a lower sealing edge 33, which may be pressed against the groove base 34 of the groove 21.

The stabilizing element 26, in the form of a toroidally curved coiled spring, is laid between the C-profiles 28 of the sealing rings 24, 25. The threads of the coiled spring are - as shown in Figures 3a and 3b - slanted by an angle 35 of approximately  $10^\circ$  in relation to the longitudinal axis 36 of the coiled spring. The coiled spring may therefore be laid radially (in relation to the piston 12) compressed between the sealing rings 24, 25, through which a pre-tension of the sealing rings 24, 25 in the radial direction is produced. A support ring S, which is only illustrated in Figures 1c and 2, is laid in the coiled spring for mounting purposes.

As shown in Figure 4a, the sealing lips 27 project slightly out of the groove 21 when valve 1 is open - just far enough that they come into contact with the mantle surface 18 of the piston 12 in the blocked position and close the annular gap 19 between the

mantle surface 18 of the piston 12 and the cylinder 9. In the blocked position - illustrated in Figures 4b and 4c - any increase of the differential pressure between valve intake 2 and valve outlet 3 of the valve 1 causes self-reinforcement of the sealing effect of the annular gap seal 20 ~~according to the present invention.~~

~~In the operating case shown in Figures 4b,~~ Figure 4b shows the pressure at the valve intake 2 is higher than at the valve outlet 3 in the blocked position. This is - in the intended flow direction 4 - the normal case: in relation to the particular pressures, the high-pressure side 37 is at the valve intake 2 and the low-pressure side 38 is at the valve outlet 3 ~~here~~. A pressure gradient forms between the sealing rings 24, 25: an average pressure lying between the pressure on the high-pressure side 37 and the pressure on the low-pressure side 38 initially forms in the intermediate space 39 between the C-profiles 28.

Under the influence of the particular applied pressure differential, the sealing rings 24, 25 deform. The ~~the~~ inner sealing ring 24 (1) is radially compressed by the pressure of the high-pressure side 37, which is higher than the average pressure, (2) temporarily presses against the stabilizing element 26, and

(3) eases the pressure equalization between the high-pressure side 37 and the intermediate space 39 between the C-profiles 28 through the annular gap 19, which is thus enlarged. The outer sealing ring 25 is radially expanded by the average pressure, which is higher than that of the low-pressure side 38 - and/or later by the pressure of the high-pressure side 37. ~~[[ - ]] and its~~ Its outer sealing surface 29 presses against the groove wall 30, in particular its sealing shoulder 31 presses against the lug 32 implemented on the groove 21. In addition, the sealing edge 33 of the outer sealing ring 25 is pressed against the groove base 34 with increasing pressure differential. Furthermore, the pressure of the sealing lip 27 of the outer sealing ring 25 on the mantle surface 18 of the piston 12 is elevated by the radial expansion. Overall, the sealing action of the annular gap seal 20 is increased.

~~The operating case illustrated in Figure 4c corresponds to Figure~~ 4c shows the case of a - typically undesired, but usually occurring precisely in the event of rapid switching procedures - backflow against the intended flow direction 4. In relation to the normal case illustrated in Figure 4b, the high-pressure side 37 is now implemented at the valve outlet 3, and the low-pressure side 38 is implemented at the valve intake 2. Because of the



mirror-symmetric construction of the annular gap seal 20, the outer sealing ring 25 is now radially compressed here and the inner sealing ring 24 is radially expanded. The sealing action is thus also increased for the case of a flow against the intended flow direction 4 using the annular gap seal 20 ~~according to the present invention.~~

Although at least one embodiment of the present invention has been shown and described, it is apparent that many changes and modifications may be made thereunto without departing from the spirit and scope of the invention.

List of reference numbers

- 1 valve
- 2 valve intake
- 3 valve outlet
- 4 intended flow direction
- 5 nominal diameter
- 6 flange surface
- 7 overall length
- 8 housing
- 9 cylinder
- 10 cage
- 11 outlet bush
- 12 piston
- 13 spoke
- 14 piston rod
- 15 surface
- 16 surface
- 17 switch rod
- 18 mantle surface
- 19 annular gap
- 20 annular gap seal
- 21 groove
- 22 groove
- 23 lip seal
- 24 inner sealing ring
- 25 outer sealing ring
- 26 stabilizing element
- 27 sealing lip
- 28 C-profile
- 29 sealing surface
- 30 lateral groove wall

31 sealing shoulder  
32 lug  
33 lower sealing edge  
34 groove base  
35 angle  
36 longitudinal axis  
37 high-pressure side  
38 low-pressure side  
39 intermediate space  
S support ring